Reduction of the Negative Differential Pressure by Using a Piccolo-type Igniter to the 40mm KE Ammunition

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40mm APFSDS-T Ammunition

The projectile fracture experienced

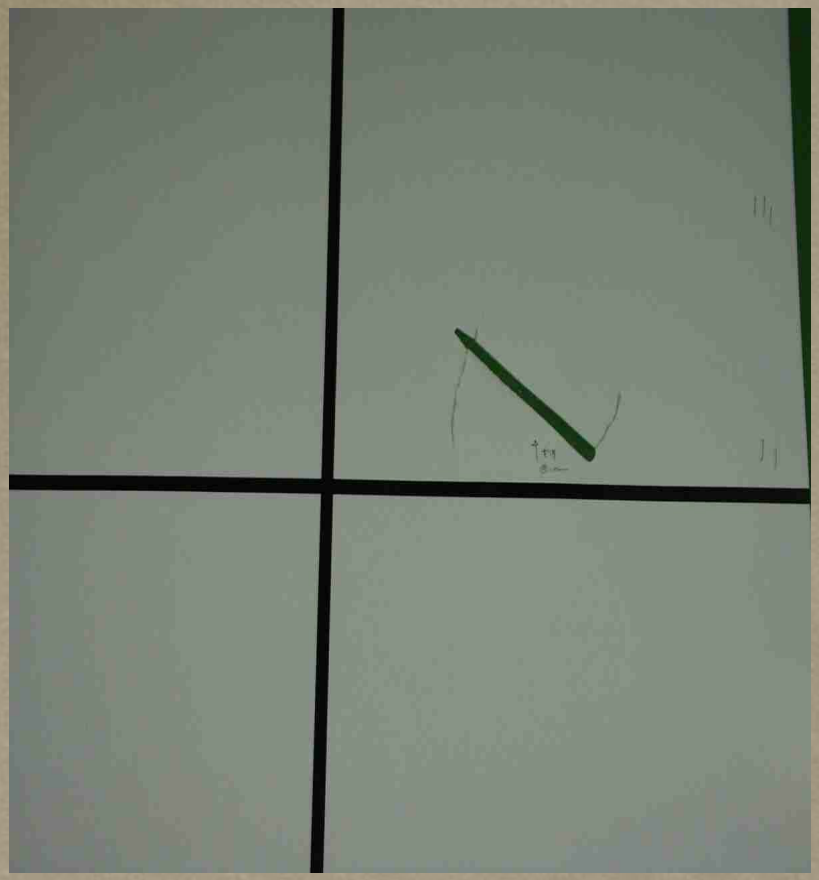
- In-bore security problem
- Evidence
  - **Footprints in yaw cards(hard boards)**
  - **Still video records**
  - **Doppler radar data**
  - **Recovered debris**

The projectile fracture experienced(2/6)

- Footprints in yaw cards
  - **@ 20m fr. Muzzle**
  - **Penetrator broken into 3 pieces**

The projectile fracture experienced(3/6)

- Footprints in yaw cards
  - **@ 20m fr. Muzzle**
  - **Broken penetrator**
  - **Fin Missing**



The projectile fracture experienced(4/6)

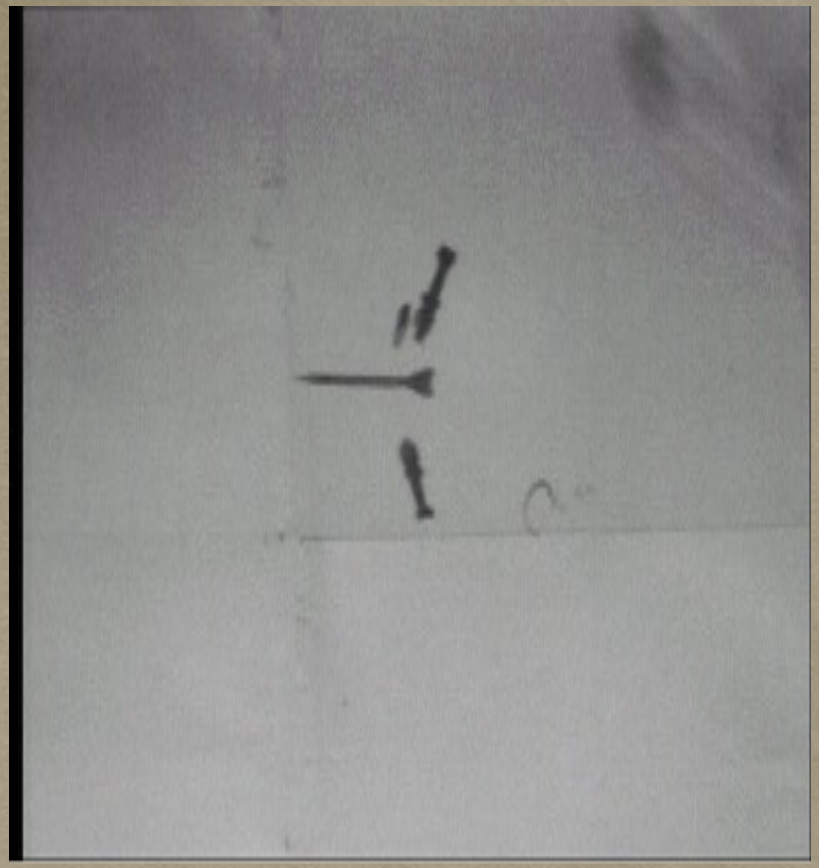
- Footprints in yaw cards
  - **Normal marks**
  - **@ 20m fr. Muzzle**
  - **(center) penetrator with a stabilizing fin 3 rounds**
  - **(left below) sabot**
  - **(right up) sabot**

The projectile fracture experienced(5/6)

- Still video records
  - **Fractured projectile**
  - **@ 7m fr. Muzzle**
  - **Sabot + penetrator + fin**

The projectile fracture experienced(6/6)

- Still video records
  - **Normal projectile**
  - **@ 7m fr. Muzzle**
  - **Penetrator/fin + sabot(3 pieces)**



What’s the problem?

- Probable Causes
  - **Defects**
  - **Design error**
  - **Unexpected high pressure**
  - **The others**

What’s the problem?(2/5)

- Defects
  - **NDT**
    - Penetrator
    - Sabot
    - Stabilizing Fin
  - **Alignment gage test**
    - Complete round

What's the problem?(3/5)

- Design characteristics
  - **Maximum design strength**
    - 80,000psi
  - **Stress concentration**
    - Designed to avoid as possible
  - **Safety factor (estimated)**
    - SF= 2.0

What's the problem?(4/5)

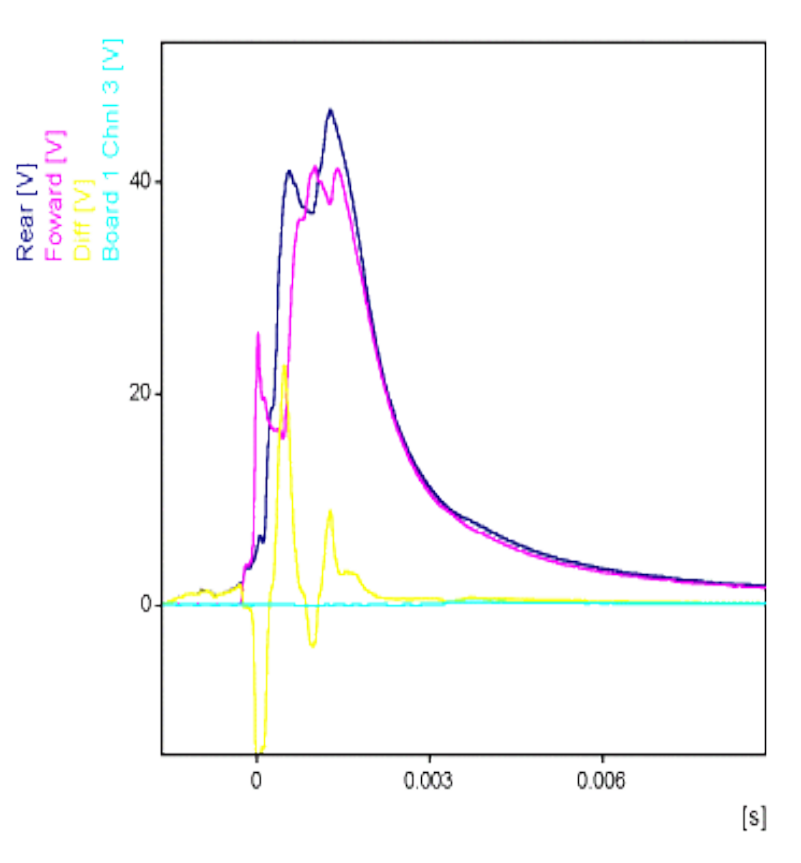
- Unexpected high pressure
  - **Measured max. pressure: 65,000psi**
    - Piezotransducers: PCB
    - Gage Locations: 90mm, 280mm from RFT
  - **Max. design strength > calculated strength**

What’s the problem?(5/5)

- The others
  - **Negative differential pressure(NDP)**
    - Pressure history curves → yes

Negative differential pressure

- NDP
  - **Gage locations**
    -Rear:@ 90mm
    -Fwd:@ 280mm
    from RFT
  - **P_{max} ≈ 65,000 psi**
  - **-Δp ≈ 25,000 psi**
- Abnormal burning

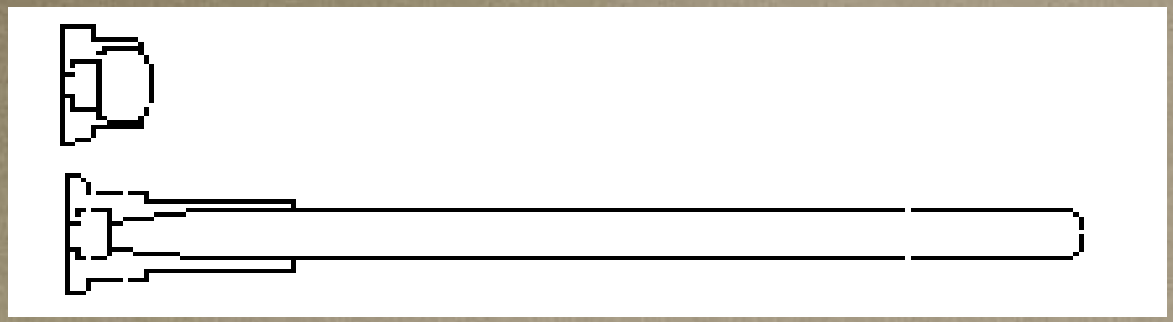


Negative differential pressure(2/2)

- Anther evidence was found
- Cartridge case
  - **Rear face of the cartridge case**
  - **Blow back marks**

The approach adopted

- Primer redesign
  - **Button-type → Piccolo-type**
  - **Base burning → Center-core burning**



The approach adopted(2/4)

- Design parameters
  - **No. of holes in the flash tube**
  - **Length of the flash tube**
  - **Diameter of a hole**
  - **Hole distribution pattern**
  - **Ignition propellant (type, quantity)**

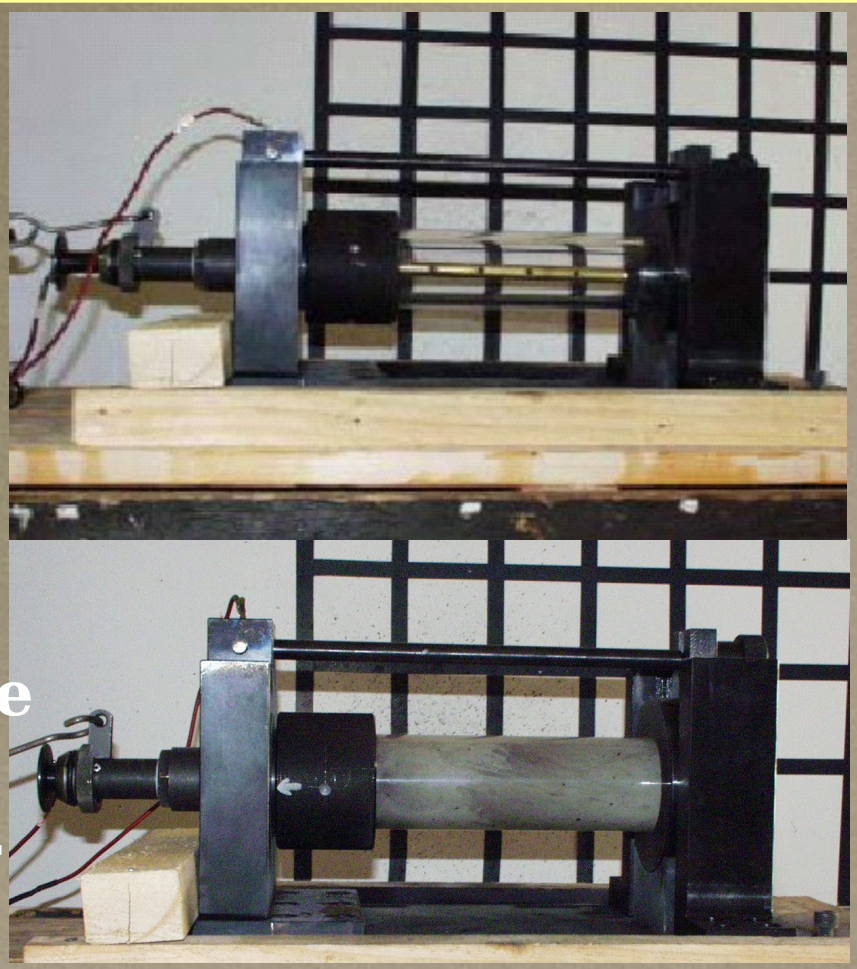
The approach adopted(3/4)

- Piccolo-type primer
  - **Length: 240mm**
  - **Ignition propellant**
    - Benite strand
    - Weight: 8.0g
  - **No. of hole: 16**
  - **Hole pattern: 4-row**
  - **Diameter of a hole**

    :φ 3.2mm

The approach adopted(4/4)

- Test apparatus
  - **Transparent window**
  - **Grid**
  - **Primer**
  - **(above)before firing**
  - **(below) after firing**

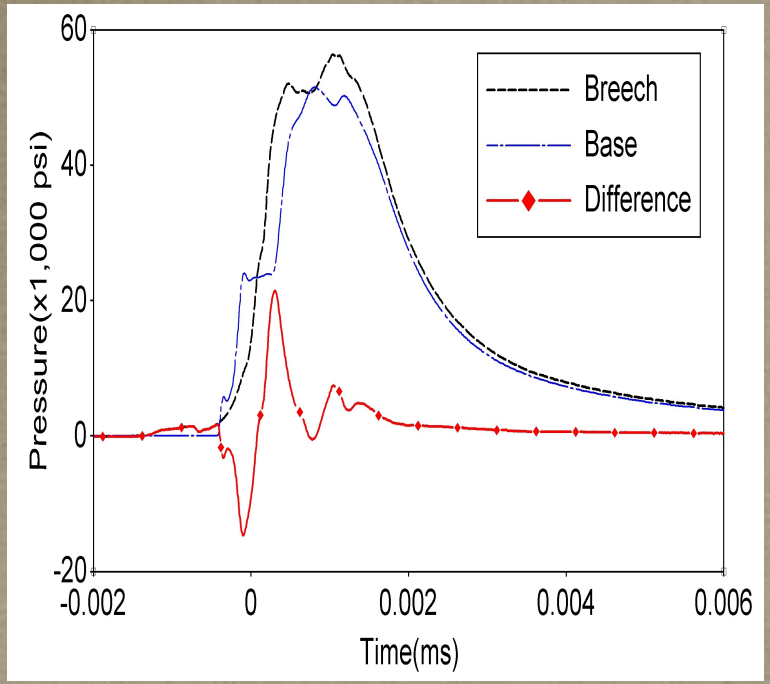


Results achieved

- Hole opening phenomena
  - **High speed digital video camera**
  - **Frame: 4,000frames/second**
  - **5.0msec after percussion (firing)**
  - **(above) Button-type**
  - **(below) Piccolo-type**

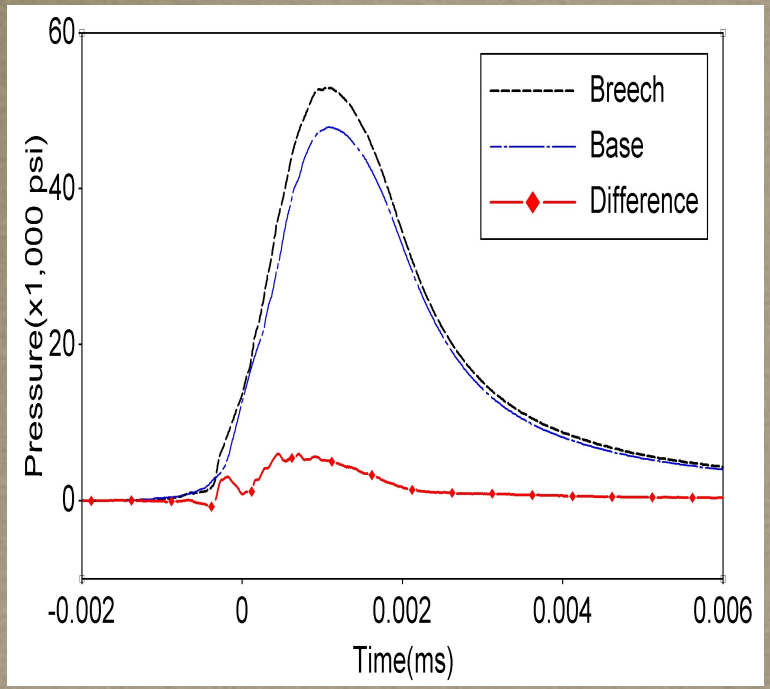
Results achieved(2/4)

- Pressure history
  - **Button-type primer**
  - **P_{max} = 56,000psi**
  - **-ΔP = 15,000psi**
  - **Gage locations**
    -breech: @90mm
    -base: @280mm
  - **Multi peaks**



Results achieved(3/4)

- Pressure history
  - **Piccolo-type primer**
  - **P_{max} = 55,000psi**
  - **-ΔP = 2,000psi**
  - **Gage locations**
    -breech: @90mm
    -base: @280mm
  - **Mono peak**



Results achieved(4/4)

- Finally, when the piccolo-type primer was used in 40mm KE ammunition, the in-bore security problem has been resolved.
  - **No blow back marks in the rear face of the cartridge case**
  - **No multipeaks in pressure history curves**
  - **No NDP in pressure history curves**

Thanks

The above porcelain is a goblet which depicted a knight on a horse and is assumed to be used for drinking wine or something at the oath ceremony in